Space Weather Technical Forecast

Issued on Friday, 28 July 2023 at 13:13 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Ongoing daily Chance of R1/R2 radio blackouts. Revised geomagnetic forecast now mainly Quiet.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate over the past 24 hours, with X-ray flares recorded at GOES16 showing frequent small C-class activity, but peaking with a long duration M1.7 around 27/2235UTC from AR3388 on the northeastern limb.

There are currently up to ten sunspot regions on the visible disc, with the largest and most active of recent times now having departed over the western solar horizon: Ex-AR3376. A new unnumbered region hoved into view in the southeast, manifesting as an Hrx/Alpha, but perhaps hiding detail in its surrounding plage. The main changes observed in the period have been strong proliferation of intermediate spots in AR3386, now a Dai/Beta-Gamma in the northwest quadrant; and also development of numerous small spots around the main penumbral group in AR3380, now a Csi/Beta-Gamma in the south-centre.

A large filament currently occupies the northeastern quadrant, and while there are no current signs that any lift-off is imminent, it remains something to monitor given its narrowing angle with the Sun-Earth line in the period. Also of note is the fact that the oncoming eastern limb Carringtons appear to harbour CME-generating areas (with CMEs seen heading northeast and southeast from the limb in recent hours' coronagraph imagery) that may well correspond to large active regions here. Other CME activity was mainly observed from the southwest limb.

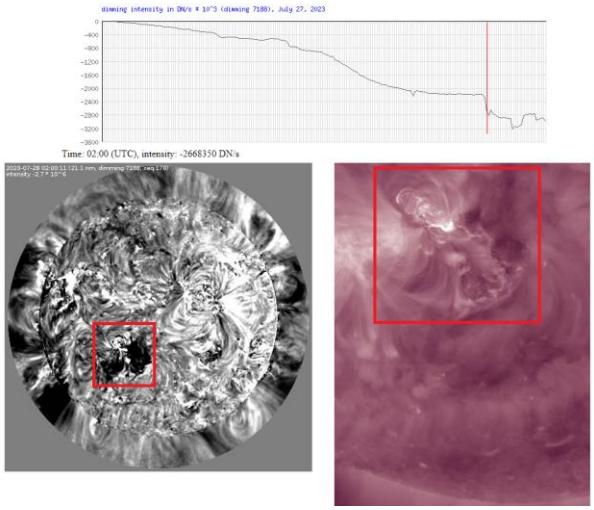


Figure 0: Lower left: time-integrated AIA211 dimming (processing courtesy SIDC ROB), showing boxed red an event of potential note from AR3380, also shown in a single false-colour AIA211 image, lower right; also a graph of the intensity of the dimming (above). The automatic dimming detection is long-period due to preceding east limb activity.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Perhaps the most noteworthy event of the period was a C7 flare from the vicinity of AR3380 was observed around 28/0200UTC. This had an accompanying AIA 211 dimming and small EUV wave, which may perhaps indicate a CME may have been generated, although as yet the evidence is not clear from coronagraph imagery.

The previously advertised small filament around 27/1330UTC was further investigated and no CME was found, with no effect therefore anticipated.

At present then, there are no confirmed new Earth-directed CMEs, although imagery for the possibly generative event from AR3380 at 28/0200UTC is awaited. Very tentatively, a partial arc of ejecta may have been identified heading south and southwest of the Sun-Earth line in UTC morning coronagraph imagery which would intersect the Sun-Earth line - with a speed of around 400km/s. Further analyses will be conducted before any submission for modelling.

Solar Wind / Geomagnetic Activity: The solar wind, as measured at L1 by DSCOVR and ACE, was reflective of a weak connection with a positive polarity (phi away from the Sun) high speed stream, likely that originating from CH28/+. As a result the solar wind speed fell from Slightly Elevated levels and 450km/s to Background 375, with the solar wind density falling from early peaks narrowly into double figures ppcc but falling back to within more typical single figures as the period went on. The IMF was smooth in character, at or below 7nT, with a north-south component showing slow oscillation between extremes of -2 and +4nT.

The net effect of the above solar wind measures was for provisionally Quiet geomagnetic activity throughout, peaking with a Kp of '2o' in the 15-18UTC interval.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux has been at Background levels.

GOES16 high energy (greater than 2MeV) electron flux ranged between Moderate and Normal Background flux, with a peak of 661pfu recorded at 27/1555UTC. 24-hour integrated fluence was 1.54e7 integrated pfu at 28/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: There is a daily Chance of Moderate activity, as although the recent most active sunspot group (Ex-3376) has now departed the disc, there are signs of a busy eastern solar limb from recent CME evidence.

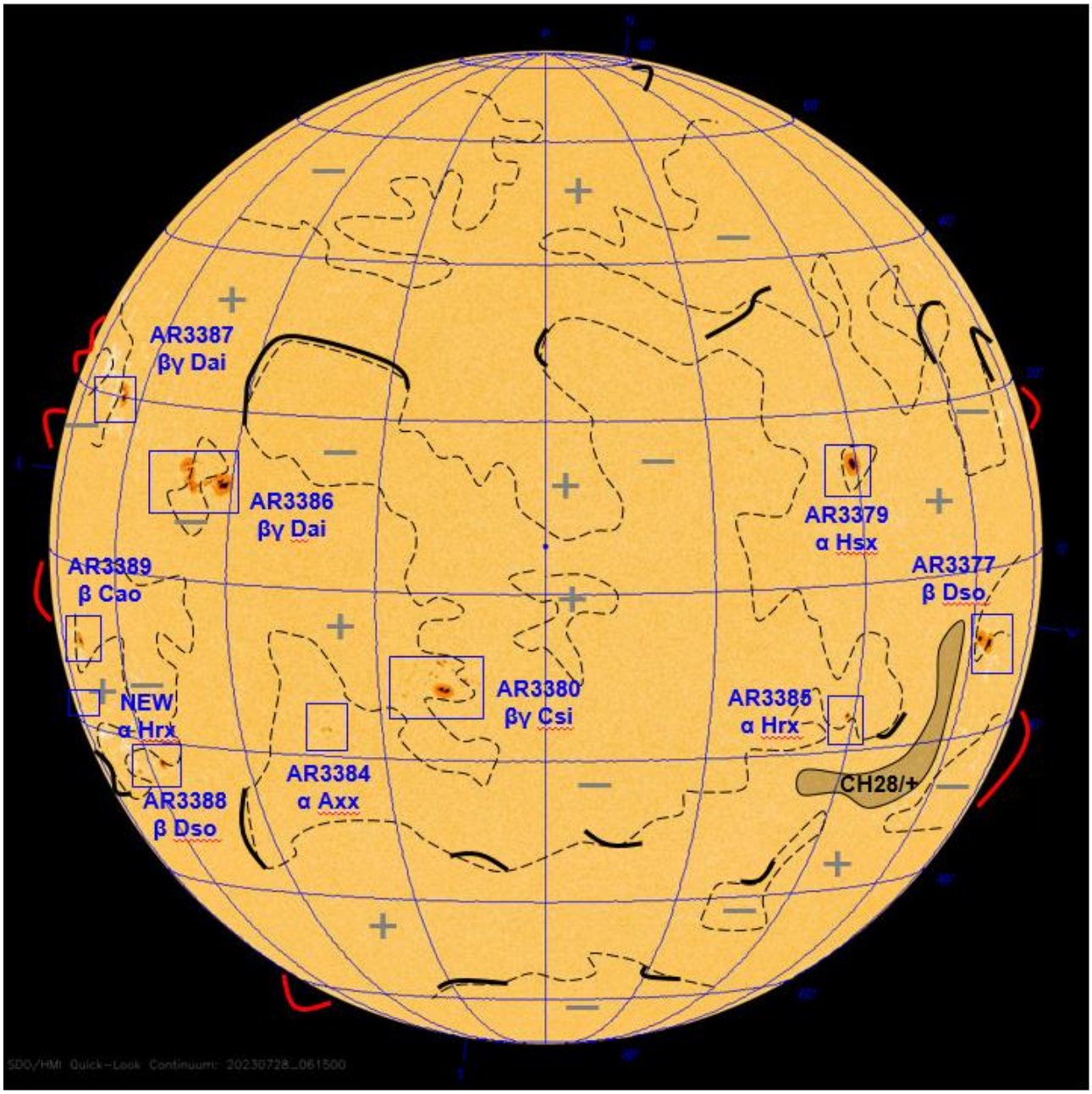
Solar Wind / Geomagnetic Activity: Contrary to earlier guidance, no CMEs are now thought to be en route. The sole fast wind in the period is the one manifesting at Earth at present, and a continued gradual exit is expected into the coming UTC weekend to leave predominantly Quiet conditions throughout.

Energetic Particles / Solar Radiation: There remains a slight chance of the high energy (greater than 10MeV) proton flux increasing from any further significant flares that occur. This risk reduces a little through the period as Ex-AR3376 rotates further from the northwestern limb. The high energy (greater than 2MeV) electron flux is likely to rise as wind speeds ease, but the associated fluence is forecast to remain below the Active (1e8 integrated pfu) threshold during this period.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 1. Solar Analysis Valid 28/0615UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Geomagnetic Storms:

A revised interpretation of a filament from the southwest quadrant on 27 July now shows no Earth-bound component, and no CMEs now feature in the forecast.

The only fast wind expected in the coming four days is that from currently geoeffective CH28/+, and this has peaked to little geomagnetic effect. The central portion of the disc is the preserve of several weakly-defined candidates for minor coronal holes in AIA211, however none are thought noteworthy, and instead a gradual decay to Quiet geomagnetic conditions is favoured. This runs counter to the latest MOSWOC Enlil model run(s), which suggest an imminent weak ecliptic-crossing 450km/s positive-polarity fast wind. This does perhaps lower confidence in the immediate term, however the fact remains that even if this is present it is not likely to be impactful (on the G-scale). STEREO A MAG and PLASTIC currently show no signs of any further fast wind enhancement, although this only now represents a roughly eight-hour lead time given STEREO's proximity to Earth.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	1	1	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

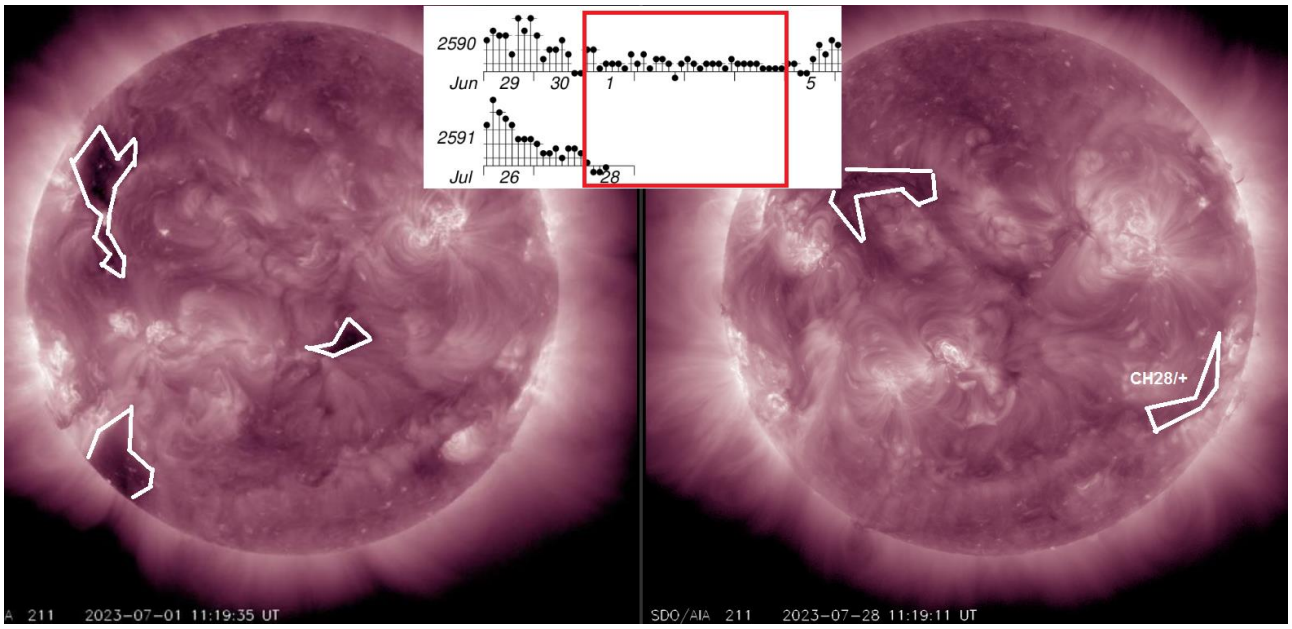
Geomagnetic Activity - Earthbound Coronal Mass Ejections

Nil.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 2: Past and current rotations' coronal hole configurations, with resulting geomagnetic activity inset as a Bartels music plot. No notable features are expected, and the Quiet four-day persistence forecast is likely to be repeated as a result.



Radio Blackouts - X-Ray Flares:

Solar activity has been Moderate over the past 24 hours, with an M1.7 observed around 27/2235UTC from AR3388 (in the southeast quadrant).

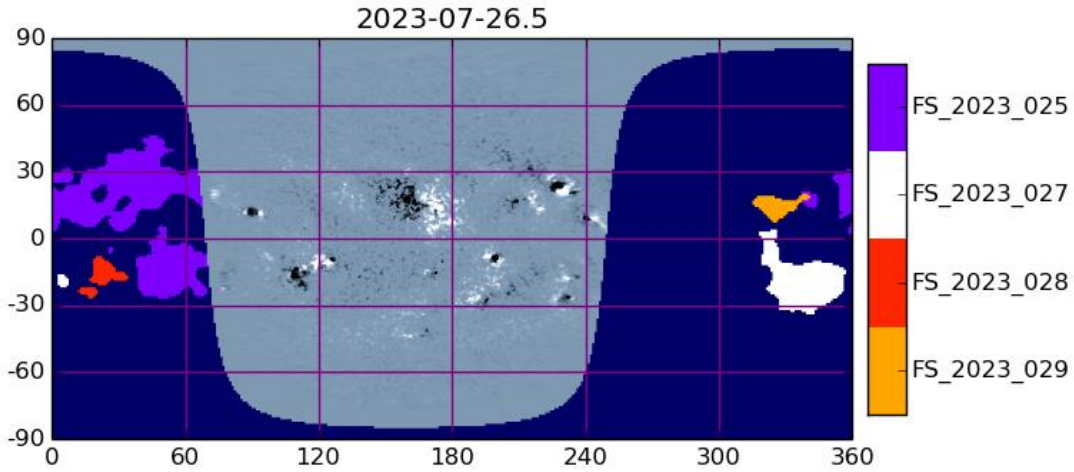
Far-side soundings and recent CME evidence would suggest that the arriving eastern solar horizon of the coming UTC weekend is likely to reveal more potentially complex regions than those leaving the western limb, although Ex-AR3376's recent departure is perhaps the exception. Until any regions present over the arriving limb for analysis, the daily Chance of M-class is held constant, but with a tentative negative outlook proffered.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	50	50	50	50
Very Active	R3 to R5 X Class	No	5	5	5	5

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 3: Far side soundings as of 26/1200UTC, showing potential returning regions as they then appeared (roughly between Carringtons of 45 and 350).



Solar Radiation Storms - (High Energy Protons):

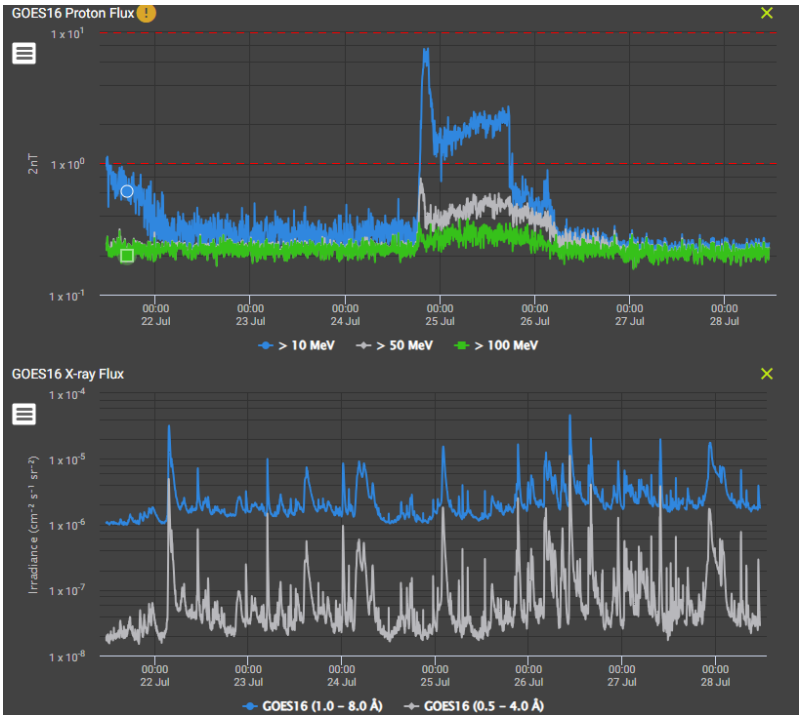
The high energy (greater than 10MeV) proton flux observed by GOES16 is at background levels and will most likely remain so throughout the period. There does remain a very slowly waning daily Slight Chance of reaching the S1 Minor Storm threshold given Ex-AR3376's position, which is far-sided but near the northwestern limb. The risk from this region probably slightly outweighs the that from the westward progression of the active eastern solar hemisphere groups, and its waning trend therefore trumps the growing one from the frontside cohort.

Radiation Storms	**Level (cm^{-2} sr^{-1} s^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ S1**	No	10	10	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 4: Past week in GOES16 high energy proton flux (top) and X-ray flares (bottom), showing no clear link between observed enhancements in this period and front-sided activity. The near-S1 event of 24 July was tenetiavely associated with a far-sided event.



High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) levels have ranged between Moderate and Normal Background in the last 24 hours.

The fast wind emanating from CH28/+ may have been ongoing since at least the second half of the UTC of 26 July, with its onset perhaps slightly clouded by the preceding CME. As such, given the recent lack of geomagnetic activity, the Van Allen belts ought to be near an equilibrium population for this fast wind, and any exceedence of Active 24-hour fluence now looks unlikely.

Given the lack of any further forthcoming enhancements, levels reached into the coming UTC weekend ought to be near the peak for the period, and the chances of Active fluence therefore soon saturate to peak at Slight. The MOSWOC REFM forecast is therefore considered a reasonable guide in diverging from the last rotation's narrow exceedence of Active in the next 72-hours, instead declining day-on-day from current flux levels.

GEO Electron Environment	**Level (cm^{-2} sr^{-1} day^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ 2 MeV ≥ $1x10^8$**	No	10	20	20	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 5: Past week in high energy electron flux (top); L1 solar wind (middle, ACE shaded yellow); and BGS actual Kp. The current electron flux diurnal oscillation is thought to lie close to an equilibirum state, and little change is therefore expected in the absence of further geomagnetic drivers in the period.

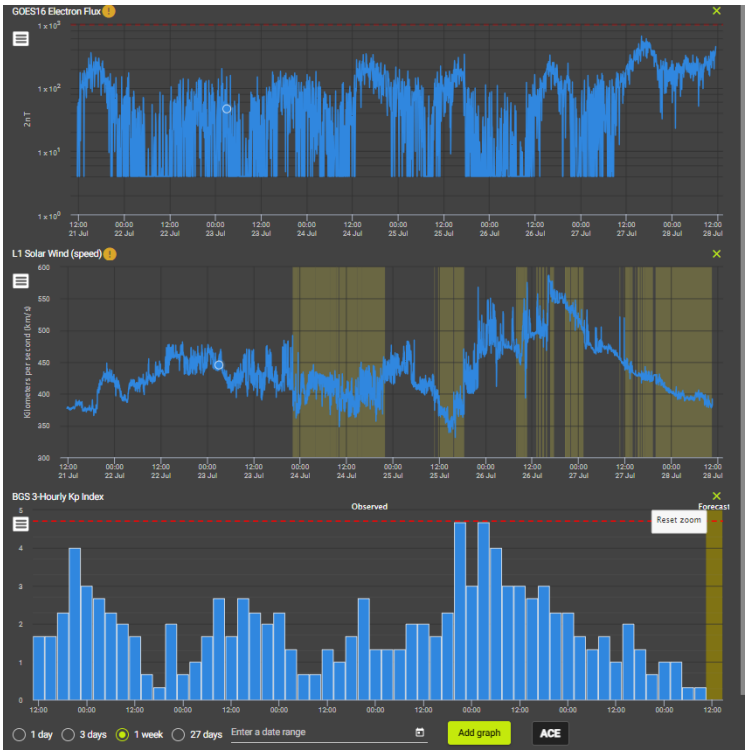
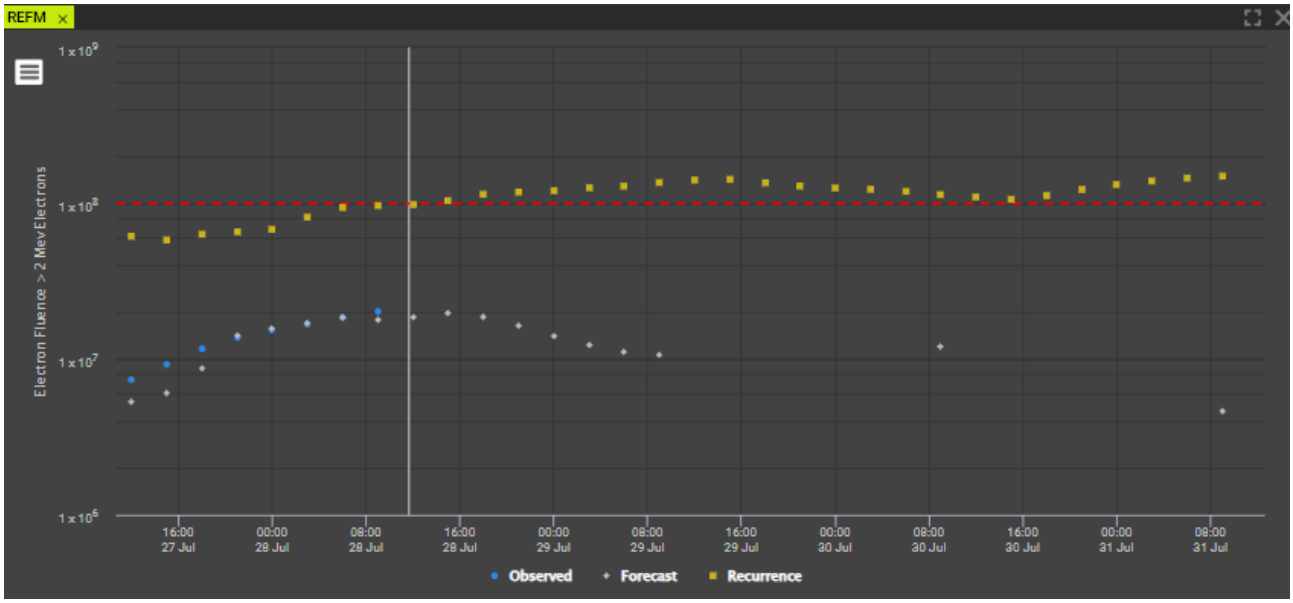


Figure 6: Latest MOSWOC REFM, showing divergent trend with persistence which is accepted given the expected lack of further fast wind signatures.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.